MATERIALIST DIALECTICS AS A PHILOSOPHICAL BASIS FOR SYSTEMS RESEARCH

J. M. Gvishiani

In: GVISHIANI, Dzehermen Mikhailovich. *Systems Research: Methodological Problems*. Pergamon Press, 1984. p. 3-15

Through constant expansion of its social role science has become a major tool for controlling the development of human society. While exercising this function science itself undergoes quantitative and qualitative changes which follow two trends: differentiation and integration of its various domains. L. I. Brezhnev pointed out that "fresh opportunities for fruitful general theoretical, fundamental and applied research arise in interdisciplinary areas, notably in the natural and the social sciences" [3].

The integrative trend appears at its most productive in systems research, which is a vigorously developing area with only a few decades to its history. Systems research treats complex, multiple, large-scale problems (including global socioeconomic ones) and consistently seeks not only to get to the heart of the matter but to devise ways and means for a rational control of the objects in question and to promote the solution of the problems on hand. This unity of study and transformation is responsible for the comprehensive interdisciplinary nature of systems research.

In the Soviet Union and other Socialist countries systems research is founded on the philosophical basis of materialist dialectics. This paper offers a substantiation of this conception.

DIALECTICS AND THE PHILOSOPHIC SYSTEMS PRINCIPLE

Before tackling the main subject of this paper I shall first introduce some definitions. A system in the most general sense is defined as *a complex of interrelated elements forming a whole*. This understanding of a system imposes no constraints on the nature of the constituent elements (they may be material objects or ideal structures) or the kind of whole formed (it may vary from a mechanical sum of externally connected material objects to, in Marx's words, an organic integrity like that of a living creature, the human brain, the organized structure of a large industrial enterprise, a social structure). The main task of systems research lies in the analysis and construction of various systems and the control of natural systems. It is essential to distinguish between systems as objects of study, construction of problems inherent in an object system or important to the subject (researcher).

{p. 4}

Systems research is a rapidly developing sphere of science and technology and it requires a philosophic substantiation. Of fundamental importance here is the philosophic systems principle which asserts that "a phenomenon of objective reality viewed in terms of a systematic whole and the interaction of its constituent elements is a specific cognitive prism or a specific 'dimension' of reality" [17, p. 10].

Apart from its concrete scientific value, the systems principle has a broad conceptual significance; it is the upshot of a long evolution of natural science and

philosophy.

The principle itself first came to be understood within the framework of 16th century natural philosophy which strove to "systematize" the knowledge about nature obtained by concrete sciences. In reality, however, natural philosophy did not go further than a quasi-systematic approach which consisted in a fixed classification or a metaphysical arrangement of all things within an unchangeable universal "system". Along with the first realization of the systems principle, this was, in fact, the first manifestation of the tendency to use the term "system" loosely to describe any more or less organized totality of objects.

Schelling and then Hegel put in a great deal of effort to join "systemization" to development. However, the idealist conception of the natural and social world as a reflection of an absolute idea led both thinkers to enclose the systems principle inside philosophy itself, which left the dialectic principle of development crushed in the Procrustean bed of metaphysics.

Nevertheless classic German philosophy made a big step forward by demonstrating that object-knowledge or knowledge about objects *per se* is but direct, simple knowledge which must serve to attain essential, substantial or systematic knowledge that treats an object as part of a broader system. This idea was clearly laid down by Hegel in his *Encyclopedia of Philosophic Sciences*:

> Unless it is a system, a philosophy is not a scientific production. Unsystematic philosophising can only be expected to give expression to personal peculiarities of mind, and has no principle for the regulation of its contents. Apart from the interdependence and organic union, the truths of philosophy are valueless, and must be treated as baseless hypotheses, or personal convictions. Yet many philosophical treatises confine themselves to such an exposition of the opinions and sentiments of the author [11, vol. I, p. 100].

The systems principle found its first truly scientific expression in the works of Marx and Engels. The dialectic materialist treatment of the natural and social world freed the systems principle as well as the principle of development from intra-philosophic confinement. This is how Engels characterized the unity of these dialectic principles as applied to material reality in *Dialectics of Nature*:

> The whole of nature accessible to us forms a system, an interconnected totality of bodies, and by bodies we understand here all material existences extending from stars to atoms .... In the fact that these bodies are interconnected is already included that they react on one another, and it is precisely this mutual reaction that constitutes motion. It already becomes evident here that matter is unthinkable without motion. And if, in addition, matter confronts us as something given, equally uncreatable as indestructible, it follows that motion also is as {p. 5} uncreatable as indestructible. It became impossible to reject this conclusion as soon as it was recognized that the universe is a system, an inter-connection of bodies [1, vol. 20, p. 392].

In *Capital* Marx applied the systems principle in organic unity with the principle of development to the analysis of a concrete socio-economic system and used it to create a theory of that system. This application bore rich fruit for the systems principle

itself: systems properties were shown to exist as integral properties of a system; social phenomena were found to be peculiar in that man doubles himself in the things he creates and the nature he transforms, i.e. natural qualities are supplemented with man-made social qualities in the "second nature"; there is a duality to the social qualities themselves, as in the dual nature of labour. The evolution of mankind is regarded by the Marxist theory as onward motion from systems with a predominance of natural determination, and within the latter category from an economic entity to a higher truly social community. Marx's elaboration of the systems principle yielded the fundamental conclusion that real objects in general and social phenomena in particular belong to several systems instead of one. Hence any real, i.e. truly concrete, knowledge is polysystemic instead of merely systemic.*

Thus in materialist dialectics the systems principle is joined organically to the principle of development and performs methodological functions with regard to both ontology and the theory of cognition. To discover the polysystematic nature of scientific knowledge one needed an understanding of the infinity and inexhaustibility of systems relations in the objective material world. Therefore one is fully justified in saying that "the systems principle is one of the major components of marxist theory and methodology" [17, p. 20]. The subsequent development of philosophy and special sciences has fully confirmed the materialist dialectic interpretation of the systems principle.

The crisis that struck the methodology of natural science at the turn of the twentieth century and was profoundly analysed by V. I. Lenin in *Materialism and Empiriocriticism* [2] led most naturalists to renounce the mechanistic conception of the world as a sum of separate unchangeable elements and accept the dialectical view of the world as an evolving systematic whole. The rapid development of science in the twentieth century not only deepened and refined the philosophic notions and principles of scientific cognition but altered and enriched the entire machinery of scientific categories, leading *inter alia*, to a greater significance of the general scientific concepts and the elaboration of general scientific methodological principles and approaches. It is in this sphere that the struggle between materialism and idealism in scientific cognition came to be centered: the neopositivists regarded the general scientific approaches and concepts as a substitute for philosophy while the materialists saw them as a new proof of the efficiency of materialist dialectics, a new expedient for an adequate reflection of reality and its more effective transformation by man. The new general scientific {p. 6} methods which appeared in the middle of the twentieth century and later became widespread include systems approach, various versions of general systems theory and systems analysis.

Contemporary literature (including Marxist literature) offers rather discrepant definitions of the basic principles and content of the above domains of systems research (see for instance [5], [6], [15], [20], [25], [28], [29], [31]). This is only natural: systems research, especially practical systems studies, are as yet in the making and premature rigid definitions that take no heed of the practical expediency and effectiveness of the theoretical generalizations (still to be obtained and verified) can only hamper the progress of systems research as a whole. Meanwhile we do need some *ad hoc*

* For detailed treatment of this and other aspects of systems thinking in Marx's doctrine see *The Systems Principle Marx's Theory and Methodology* by V. P, Kuzmin [17]. The author rightly points out that "K. Marx and F. Engels left us no special study of the systems problem in the form of a ready-made methodological theory but they did leave a systems theory of a social development and multiple instances of concrete systems solutions of various questions arising in the study of society as a whole" [17. p. 12].

definitions of systems approach, general systems theory and systems analysis, so in the context of the subject on hand, i.e. the substantiation of materialist dialectics as a philosophic basis for systems research, the following points should be emphasized.

Systems approach, general systems theory and systems analysis are all aspects or sides of contemporary systems research. They have a number of properties in common as well as their own distinctive features. The common properties are:

(1) The theoretical methodological function: each of them is a form of theoretical interpretation of systems research which generalizes the experience of concrete systems studies in its own special terms and serves as a methodological tool for further systems research.

(2) The general, interdisciplinary nature: the objectives of systems approach, general systems theory and systems analysis make it impossible to inscribe any of them in the current subject-wise division of science and technology while the results they yield are applicable to whole complexes of scientific and technical disciplines.

As for the specificity of these three domains of theoretical reflection about systems research, it lies in the peculiar form of reflection inherent in each domain. The specific purpose of systems approach is the formulation of principles, notions and methods of systems research at the level of special methodology with due regard for the general methodology, i.e. materialist dialectics. Systems analysis mostly deals with the elaboration of theoretical methodological procedures for systems studies, the construction of systems and the control of systems involving the human (goal-oriented) factor. The general systems theory, in the opinion of those who were the first to program such a theory (L. von Bertalanffy [15, pp. 23-82], M. Mesarovic [15, pp. 165-186], K. Boulding [15, pp. 106-124] and others), should be a kind of general science covering all types of systems. However, the practical implementation of the various programs for the creation of a general systems theory has met with tremendous difficulties. Therefore at the moment general systems theory usually means a more or less generalized version of a systems theory, embracing certain classes or types of systems. Besides, there exists a logical methodological interpretation of general systems theory as a metatheory of systems theories.

Once again I would emphasize the provisional nature of the above definitions which have no claims at all to finality or completeness.* The common and {p. 7} specific features of systems approach, general systems theory and systems analysis had to be established for the further elaboration of our thesis: the fundamental role of materialist dialectics at the philosophic basis of systems research.

It follows from the above understanding of systems approach, general systems theory and systems analysis that these spheres of contemporary systems research, though designed to give a theoretical generalization of practical systems studies, are themselves in need of a philosophic interpretation and substantiation. Although systems approach, general systems theory and systems analysis provide theoretical methodological knowledge about systems, none of them claims philosophic generality of global conceptual significance. This role is reserved for materialist dialectics and first of all for the philosophic systems principle, which is a kind of Ariadne's thread for the philosophic interpretation of the role and significance of systems research (see also [7]).

This is how Marx enunciated the theoretical basis of the dialectic approach to

* For a more thorough analysis of the specific features of systems approach and systems analysis see the chapters by V. N. Sadovsky [26] and E. L. Nappelbaum [23] in this book.

systems:

> This organic system as an aggregate whole has underlying origins of its own and its evolution toward wholeness consists precisely in subordinating to itself all elements of society or creating therefrom the elements that it still lacks. Thus in the course of historical evolution the system becomes a holistic entity. The development of the system into such an entity constitutes a moment of the system's process and evolution [1, vol. 46, part I, p.229].

The dialectical unity of the systems principle and the principle of development is an important point in the philosophic substantiation of systems research. In this context a system is not just a structured sum of elements but a dynamically organized entity in the process of development. Of course this dialectic unity of system and development cannot but be conflicting. If the contradictory nature of complex systems seems frightening to the metaphysical outlook, the dialectic materialist doctrine regards this very contradiction as the true source of their regular development. It is through rational action on this source that a systems process can be controlled. Allowance for the unity of system and development makes it clear, *inter alia*, that the forecast of a structure cannot be based on a simple extrapolation in time of the present state of the system (e.g. a global system). The parameters of a system and its relation to the environment change in time according to the dialectic laws of progressive advance, hence systematic control can be applied to scientific and technical progress and, more generally, to socio-economic development. In short, the fundamental difference between the dialectical and the metaphysical approach consists in the formers well-founded orientation towards the objective tendency of systems to evolve.

Apart from this ontological side of the matter, there is the methodological side, specifically the role of systems studies in the integration of present day scientific and technical knowledge. Here again materialist dialectics, specifically the philosophic systems principle, is fundamental to the systematic synthesis of knowledge.

The integration of knowledge is an inherently historical problem that has been raised in different forms at various stages of scientific progress. For instance, it has been suggested that the synthesis of knowledge should be achieved on the basis of one leading discipline, and this part of the leader {p. 8} and integrator of all science was assigned to mechanics, physics, biology, or cybernetics. Of course this kind of analysis will go on in spite of its inevitable one-sidedness that makes real integration impossible, albeit it often allows a good grasp of the common features in the methodology of various sciences. But we must stress the importance of systems approach and systems analysis with respect to the integration of knowledge. Within the framework of these methods special sciences keep their independence and qualitative specificity and are not reduced to one leading science, whereas their facts and theoretical structures are centered round the systems techniques which serve as a general method that integrates scientific knowledge so as to increase its efficiency.

The interdisciplinary nature of applied systems studies is essential. It is the realization of an important modern form of knowledge synthesis. Of course this form is as yet insufficiently developed and largely functions as a compensatory mechanism designed not to prevent but merely to abate as far as possible the increasingly harmful effects of the excessive differentiation and occasional isolation of the existing and ever multiplying branches of science.

The comprehensive interdisciplinary systems approach is based on profound

qualitative changes in the reality of the scientific, technical and socio-economic development of society, in the means and ends of society control: the objects of control are acquiring giant size and complexity; within each object there is a growing interrelationship of patently heterogeneous factors: economic, social, ecological and technical; there is an increasing interplay of various structural levels; all processes occur at a growing rate; hence the need for a much higher quality and efficiency of control, which should be comprehensive, long-term and goal-oriented [13]. The emergence and development of systems approach is largely due to the objective convergence of the natural and social sciences, the need for a more precise and quantified description of socio-economic processes. All this lays special emphasis on the methodological principles of systems research which stem from the philosophic foundation of materialist dialectics. We now proceed to analyse these principles.

METHODOLOGICAL PRINCIPLES OF SYSTEMS RESEARCH

Systems research has come into being in response to the growing complexity of an over-technical world, which is largely due to the subject's increased activity seeking to reflect natural laws and transform nature all at the same time. To take one's bearings in this world where the natural interacts with the man-made, one needs new devices which have to be different from those applicable to a purely natural situation. Although the methodology of systems research is still in the making, one already discerns the outlines of some general methodological principles that make systems research distinct from any other kind of scientific endeavour [9, 14].

To demonstrate the specific methodological features of systems research I shall take up systems analysis the way it has been defined above.

(1) An important group of methodological principles underlying systems analysis asserts the organic integrity of the subjective and the objective in systems studies. This group comprises several closely related principles whose main difference lies in the role assigned to the subjective factor in systems research.

{p. 9}

The organic integrity of the subjective and the objective is a principle referring to the relationship between research and researcher. The dialectical materialist conception of the subject-object relations in cognition and control stipulates that the difference and interconnection between two types of systems should be taken into account: systems as objects of study and systems as tools for the organization of knowledge, seeking to solve the problems inherent in the object system and important to the researcher.

All special sciences, both natural and social, tackle the first type of systems. Systems of the second type, tools for cognition, control and other forms of human activity, are methodologically the prerogative of philosophy, particularly gnosceology, and of logic and metamathematics. Although systems analysis deals with both types of systems, it owes its name and many of its methodological features to the second interpretation of the term "system". Therefore this term will be more often used in its second sense.

Systems analysis offers a peculiar modification of the traditional subject-object relation of science which requires a rigid enough demarcation line between subject and object.

In fact systems analysis not so much investigates an object *per se* as tackles the problem situation connected with it, seeking eventually to ensure effective interaction

with the object. In this sense the objectives of systems analysis are at once narrower and broader than those of traditional research: broader because it requires the additional knowledge of who is to interact with the object and what interactions are therefore possible; narrower, or rather more specific, because our interest is confined to those aspects of the object's behaviour that have some bearing on the effectiveness of the proposed interaction. Naturally the "broadening" and "narrowing" of the object introduce some "extra subjectivity" into systems analysis and bring about a modification of the traditional subject-object relation. Besides, systems analysis normally deals with extremely complex objects, so that to assess different strategies leading to the desired interaction one uses essentially different models of the object. The result is a "target relativity" of the object's description [22, 23].

Furthermore, by virtue of its tendency to subordinate research to the proposed interaction, systems analysis gives a new significance to the principle of the unity of theory and practice which is central to Marxist-Leninist philosophy. Systems analysis consciously renounces the investigation of objects *per se* and conditions all studies by practical requirements so as to attain a pre-set goal. One may say that systems analysis has been called forth by the imperative need to investigate, construct and control those systems that are not as yet described by any mature and reliable theory.

Another aspect of the expanded subjective factor in systems research concerns people who usually enter its objects as important elements and whose individual and collective behaviour eventually determines many essential features of the system's behaviour. If the problem situation depends on the behaviour of various people, then it necessarily depends on the way these people perceive it. Therefore systems analysis lays special emphasis on the adjustment of the external view of the problem situation (on the part of the researcher and "customer") and the internal view (on the part of the system's active element).

{p. 10}

Yet another methodological principle of this group, which is closely related to the previous one, concerns the specificity of the subject-object relation with regard to "artificial" systems constructed (consciously or unconsciously) by man. It has been mentioned before that systems analysis deals with large systems whose integrity is ensured by goal-oriented human activity. This class includes large technical systems, socio-economic systems and organizational systems. Each of them, apart from the object side proper, objectifies the aims, motives, interests, tastes and knowledge of its designers. One must be able to distinguish between these two components while analysing the behaviour of such systems. Indeed the first component determines the real limitations imposed on our interaction with the system and its control, whereas the second component may, in fact must, be altered if the earlier aims have lost their attraction or if new knowledge, technologies or control strategies have emerged.

Speaking of the organic integrity of the objective and the subjective in systems studies, I should stress the point that subjectivity refers to those objects which are regarded as manifestations of one and the same system within the framework of our analysis. In fact the necessity for some kind of interaction with the object and the resulting problem situation are quite objective. The same is true of the people's behaviour which predetermines the system's behaviour. Finally, at any particular time, the aims and knowledge embodied in the design of a system are also objective. Yet, with regard to the object placed under study at a given moment in its history or, more generally, with regard to a whole class of possible interactions, these components appear in the description of the problem situation as variable, contingent and subjective.

(2) Another important group of methodological principles underlying systems analysis is concerned with the notion of structure. One might well say that the problem of structurization is all but the main distinctive feature of systems research. It is the structure that gives systems their integrity and determines the stable characteristics of a system, making it distinct from other kinds of objects. The notion of structure implies that within the framework of a given analysis a system will remain unchanged if one of its subsystems is replaced by another that meets the eventual requirements for adequate interaction with the other subsystems imposed by the system's structure. One may say that the integrity of a system is due to the synthesis of its stability, manifested as its structure, and its relative variability implied in the generalized description of the system's elements that only fixes the pattern of their possible interactions within the structure.

The structures of various systems may be highly diverse. Systems analysis mostly deals with hierarchic structures. One reason for this is that a hierarchic structure is so far the most effective way of organizing the data on an object's behaviour into operational knowledge. Another reason is that hierarchic structures naturally emerge in the course of development from the simple to the complex via fixed intermediate forms [27]. Note that the very notion of a system is hierarchic as it presupposes the unity of three basic concepts: a system as an element of a larger system which conditions its interaction with the environment, an integral entity and a sum of its own elements.

The above observations concerning the role of structure in systems analysis have far-reaching ramifications for the general strategy of systems research. Structural analysis is a tool which serves, *inter alia*, to investigate systems on the basis of functional similarity by solving "the inverse {p. 11} problem". According to the so-called black box principle, the external behaviour of the various subsystems within a fixed structure is only significant in so far as it conditions their interaction. The internal structure leading to this behaviour is immaterial. On the one hand, this allows a reduction of infinite regression from the system to its subsystems, then to its sub-subsystems, etc. releasing an avalanche-like flow of information relevant to the system's functioning. On the other hand, to approach the system one may first solve "the inverse problem", i.e. project each of the existing subsystems onto a simulated subsystem which would have the required external behaviour though possibly a different structure, and manipulate this model as if it were the real thing.

Functional similarity and simulation are widely used for investigating the important class of adaptive, self-organizing and learning systems. These systems differ from all others in that they are *a priori*, plunged into a "superstructure" of interaction with an environment whose elements may change in time, so that the subsystem in question must alter its behaviour to keep the original interaction structure intact.

The structure-conscious approach is closely related to the concept of the organic integrity of the objective and the subjective. The structure of a system should not be regarded as something unique or invariable. Systems analysis rarely deals with unambiguous structures of space distribution; most systems analysed have so-called functional structures or interaction structures whose elements may even be deprived of an absolute space localization. These are not identified *per se* but in the context of the external interaction structure which largely conditions them. It is in this sense that the structuring of a system depends on the problem situation in which the system is considered.

It is therefore possible to distinguish between the so-called goal-seeking (adaptive, learning) systems, as defined in modern cybernetics, and goal-setting systems. In the first case the structuring of the external interaction (a broader system) is

imposed from the outside, whereas in the second case it is imposed from within the system itself.

(3) Another important group of methodological principles underlying systems analysis and specifying the dialectic principle of development involves the notion of system dynamics. As a rule the integrity of a system and its structure is only manifest in the process of evolution when a change in one subsystem inevitably entails changes in others. This has been remarked by V. G. Afanasiev who described motion as a condensed expression, "a quintessence of all characteristics inherent in a whole" [5]. It is not only the various subsystems that may change in time; the system's structure also evolves, normally indicating the existence of a higher hierarchic level whose structural stability ensures the system's integrity. The changes may spring from the objective variability of the system *per se* as well as from the variability of the subject's view, i.e. the variability of the "systems for us". This is an essential point for systems comprising human beings with a changing idea of the system and their part in it.

Of course the dynamic approach is not confined to a mere statement of the system's possible change in time and the importance of studying the change in order to grasp the system's integrity. It also implies a continuous observation of the system's morphogenesis, whose current behaviour can only be understood in a broader context of development. This reasoning may account for the numerous attempts to construct an organismic systems theory which, for all its limitations, justly points out that each system has got its own inertia and its own internal sources of development.

{p. 12}

While stipulating that a system's behaviour should be studied on a broader time scale than the problem situation seems to demand, systems analysis notes the limited nature of the time frame in which a system can conceivably be observed and puts forward another methodological principle, that of observability. According to this principle, feasible observation must enable the researcher to identify a state of the system which is sufficient for predicting the system's behaviour in the case of future interactions.

(4) Another group of methodological principles underlying systems analysis is concerned with its interdisciplinary nature. The basic idea is that systems analysis deals with extremely complex objects whose description inevitably involves concepts pertaining to different traditional disciplines, so that there is a need to adjust various professional languages. The real meaning of this principle, however, goes much deeper [21]. The point is that traditional disciplines normally consider the various aspects of a system's behaviour in deliberate isolation from their cross-relations with other phenomena which lie within the scope of other disciplines. Systems analysis renders this isolation impossible, while the interpretation of "traditional" data in the context of systems interaction is as great a challenge as the "original" problem itself. This is another manifestation of the well-known systems effect: once a collection of facts forms a system, it acquires a new quality and is no longer tantamount to a simple sum of the initial facts.

Besides, the interdisciplinary approach insists on the coordination of the highly specialized paradigms that underlie (often not manifestly) the theories of individual phenomena relevant to a system's behaviour. *Inter alia*, this principle justifies the necessity for a correct combination of the formal and the informal components of systems research (see [18]).

(5) The organic unity of the formalized and the nonformalized is a major methodological principle of systems analysis. The basic advantages of systems analysis are often made out to be its high degree of formality and the application of numerical methods to problems that used to defy formalization. I believe that the main achievement of systems analysis lies elsewhere. It has already been pointed out that, for the first time ever in specialized scientific knowledge, systems analysis overtly acknowledges the major role of the "subjective" elements in control problems and elaborates scientific methods allowing for these elements.

Indeed, success primarily depends on whether one has correctly set the goal and defined the problem, and only secondarily on how well the problem has been solved, which is where formalization comes in. Hence it is emphatically recommended that the researcher should start with a thorough and comprehensive study of the problem, which is never a thing in itself but a reflection of the opinions and concerns of a certain group of people. The very first thing to do is to find out what they want and why. The more natural and "objective" the problem looks, the more closely and meticulously it should be investigated. The formulation of a problem does not always strictly correspond to its essence. Only too often an imperceptible and unconscious substitution is made at this point, resulting in an arbitrary imposition of unfounded limitations on perfectly admissible ways of solving the problem. Therefore systems analysis requires that the researcher should understand and make extensive use of the dialectic relationship between the formulation of a problem and the choice of methods for solving it.

Not a single alternative solution should be rejected *a priori*, on the basis of "self-evident" considerations, without a thorough analysis (including an investigation of the reasons why it should not be considered). As a rule it is not a search for the best of the known solutions but the discovery of some {p. 13} utterly new "dimension" of the space of alternatives that yields truly effective solutions. Therefore it is as important to look for new alternatives as to look for the best of the available ones.

Speaking of modelling in systems analysis, I do not imply that all models should be quantitative. A model may be qualitative or verbal, but it should by all means identify all the major premises and hypotheses on which it is based; these should, as far as possible, refer to the most elementary level of the model's organization and be absolutely clear and unambiguous. Then it would be possible to assess the situation's sensitivity to the assumptions made and to find out which of them are crucial and should therefore be most closely tested. The above refers to all models, including mathematical ones. It is very important to be able to quantitatively describe the object's behaviour, but we must not forget that a model is effective in so far as its basic premises are correct.

The dialectic unity of formalized and nonformalized treatment is a characteristic feature of systems approach and systems analysis. Two points here are significant. First, it is erroneous to believe that the model's formalized components alone enter systems research while the nonformalized ones are left out; on the contrary, systems studies should include the nonformalized premises. Secondly, it is not correct to identify the formalizable and the quantifiable, as new and more subtle formalization techniques are increasingly coming into use. The dialectic unity of the formalized and the unformalized, of the quantified and the unquantified, is crucial to the practical realization of systems research.

To achieve the unity of theory and practice in systems analysis it is essential to supply the model with a correct selection of criteria. Therefore the main quantitative component of systems analysis consists in a broad use of different criteria, or rather performance indices, for the various alternatives of the problem's solution. Systems analysis points out that no performance index can adequately characterize the manifold

assessments of the alternative in question, hence there is an imperative need for vectorial quality criteria which should contain various estimations of the solution's efficiency as well as evaluations of its costs, including the costs of research and implementation. Any performance index is implicitly based on some model of the situation and cannot be understood correctly without an indication of the model's nature.

Once the need for vectorial criteria was realized, inevitable changes occurred in the search for solutions. If until recently the basic principle has been that of optimization, i.e. the search for an alternative which would best meet one scalar criterion, at present the multicriterial approach is winning recognition.

The fact that systems analysis is practice-oriented by no means implies a deficiency in respect of theory. On the contrary, this orientation reflects the changed role and nature of scientific theory at the time of scientific and technical revolution. Systems analysis and systems research as a whole, while keeping within the current of the age-old tradition of rational cognition, answer entirely new questions raised by the modern epoch.

{p. 14}

REFERENCES

1. K. Marx and F. Engels, *Collected Works*, 2nd edition, Moscow, in Russian.
2. V. I. Lenin, *Collected Works*, Vol. 14. Moscow, Progress Publishers (1972).
3. L. I. Brezhnev, *Report of the CPSU Central Committee to XXVth Congress of the CPSU*. Moscow, Novosti Press Agency Publishing House (1976).
4. V. G. Afanasyev, *The problem of integrity in philosophy and biology*. Moscow (1964), in Russian.
5. V. G. Afanasyev, On the Systems Approach to Social Cognition, *Voprosy Filosofii*, 6, 98-111 (1973), in Russian.
6. I. V. Blauberg and E. G. Yudin, *The development and essence of the systems approach*. Moscow, Nauka (1973), in Russian.
7. I. V. Blauberg, V. N, Sadovsky and B. G. Yudin, The Systems Principle in Philosophy and Systems Approach, *Voprosy Filosofii* 8, 39-52 (1978), in Russian.
8. D. M. Gvishiani, *Organization and management*, Moscow (1972), in Russian.
9. D. M. Gvishiani, Dialectics and Principles of Systems Analysis, *Systems analysis and management of scientific and technological development: Abstracts of Papers, Theoretical Conference*, Moscow p. 3 Obninsk (1978), in Russian.
10. D. M. Gvishiani, Methodological Problems of Global Development Modelling, *Voprosy Filosofii* 2, 14-28 (1978), in Russian.
11. G. V. F. Hegel, *Encyclopaedia of Philosophic Sciences*, Vol. 1, Science of Logic. Moscow, Mysl' (1975), in Russian.
12. V. A. Ghelovani, A Modelling System for Global Development Processes, in: *Methodology of Systems Analysis*, Moscow, Proceedings of the All-Union Institute of Systems Studies, Part I, No. 6, 73-82 (1978), in Russian.
13. V. I. Danilov-Danilyan, Goal-Oriented Programmes and Optimal Long-Range Planning, *Economika i Mat. Metody 3*, 1150-1163 (1977), in Russian.
14. S. V. Emelyanov and E. L. Nappelbaum, Fundamental principles of systems

analysis, in: *Problems of Management in Socialist Industry*. Moscow, Economika (1974), in Russian.
15. *Studies in General Systems Theory*, Collection of translated papers (V. N. Sadovsky and E. G. Yudin Eds). Moscow, Progress Publishers (1969), in Russian.
16. E. S. Quade, *Systems Analysis and Policy Planning: Applications in Defence*. New York, Elsevier (1918).
17. V. P. Kuzmin, *The systems principle in Marx's theory and methodology*. Moscow (1976), in Russian.
18. N. I. Lapin, Typology of nonformalized components of a modelling system, in: *Methodology of systems analysis*, Moscow, Proceeding of the All-Union Institute of Systems Studies, Part I, No. 6, 5-13 (1978), in Russian.
19. O. I. Larichev, Systems analysis: problems and trends, *Automation and remote control* 2 (1975), in Russian.
20. V. S. Levchenkov and A. I. Propoy, On the general systems theory, Moscow, All-Union Institute of Systems Studies, preprint (1978), in Russian.
21. E. M. Mirsky, Interdisciplinary studies as an object of scientological investigation, in: *Systems Research Yearbook*, Moscow, Nauka (1972), in Russian.
22. E. L. Nappelbaum, Some aspects of the problem of uncertainty in systems analysis problems, in: *Systems analysis and management of scientific and technological development: Abstracts of Papers, Theoretical Conference, Moscow*, pp. 46-50. Obninsk (1978), in Russian.
23. E, L. Nappelbaum, Systems analysis as a research programme - guidelines and objectives, this book.

{p. 15}

24. I. B. Novik, *On Modelling of Complex Systems*. Moscow (1965), in Russian.
25. V. N. Sadovsky, *Fundamentals of the General Systems Theory: Logico - methodological Analysis*. Moscow, Nauka (1974), in Russian.
26. V. N. Sadovsky, The systems approach and general systems theory – state of the art, main problems and prospects for development, this book.
27. H. Simon, *The Sciences of the Artificial*. Cambridge, Mass., MIT Press (1969).
28. V. S. Tukhtin, *Reflection, Systems, Cybernatics*. Moscow (1972). in Russian.
29. A. I. Uetnov, *The Systems Approach and General Systems Theory*. Moscow (1978), in Russian.
30. J. G. Wirt, A. J. Lieberman and R. E. Levien, *R & D Management*. Lexington, Mass., Lexington Books (1975).
31. Yu. A. Urmantsev, *The Symmetry of Nature and the Nature of Symmetry*. Moscow (1974), in Russian.
32. P. N. Fedoseyev, Philosophy and integration of knowledge, *Voprosy Filosofii* 7, 16-30 (1978), in Russian.
33. E. G. Yudin, *The Systems Approach and the Principle of Activity: Methodological Problems of Modern Science*, p. 391. Moscow, Nauka (1978) in Russian.